Following Experts at Work in their Own Information Spaces

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Library: "a place set apart to contain books, periodicals, and other material for reading, viewing, listening, study, or reference..." [1]

No longer "a place set apart," digital libraries offer an unprecedented opportunity to provide users with information that is integrated into work processes rather than separate from them. Unfortunately, digital collections also run the risk of overwhelming users with excessive or irrelevant information. The Tracking Footprints project is a multidisciplinary investigation into how experts select and use information to perform complex tasks, using the results to design technology that enables more effective use of digital collections. This paper briefly describes our experience using field observation of expert clinicians treating complex patients in hospital settings [3, 4]. We show how this fieldwork has refined our understanding of the users and their tasks and how this work is guiding our development of digital library technology.

1. Initial Task Model: Familiarization

Our initial efforts focused on a physician treating a patient that he or she has never seen before. We were particularly interested in complex patients with multiple medical problems and numerous medications [2]. We expected that physicians would examine patients' records at length to gain overall familiarity with the case, in addition to searching for focused information to help solve the current clinical problem. Based on this expectation, we were designing technology that would provide a capsule overview of the entire medical record to assist with this task we called *familiarization*.

To learn more about this task, we used protocol analysis to observe physicians as they examined the patient record in response to defined clinical scenarios. Our observations did not support the familiarization model. Instead physicians focused almost entirely on data that had direct bearing on the given problem. They spent little time becoming familiar with the patient record as a whole, except when the scenario called for them to assume responsibility for ongoing patient care.

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Whether physicians were focused on near term or long term issues, we were impressed by the time, attention, and expertise they invested in selecting which documents to examine and which to ignore. Using scraps of paper or their fingers, physicians marked selected documents for later perusal, as they continued to search the remainder of the collection. Selection of a document was often based not on its content, but on its appearance, its location in the record, or other physical cues, a finding also reported by Nygren, et al. [5]. We also observed that physicians frequently made informal annotations as they selected and retrieved information. The substantial time and effort spent selecting and organizing a small subset of relevant information led us to reject our initial task model, *familiarization,* and revise our approach.

2. Revised Model: Tracking Selections

We next focused on the selection of documents by an expert engaged in a problem solving task. We observed that as an expert explores a large complex document collection, he or she makes explicit choices about which documents to examine and which to ignore. The result is a discrete path or *trace* through the collection. We conjectured that this trace might be of interest to subsequent users of the collection who were concerned with the same or a similar problem. In essence, we sought to reuse the time, attention, and expertise invested in examining the medical record. On the technology side, we investigated ways to keep track of the set of examined documents in an electronic medical record (EMR) system.

We returned to the field to determine: 1. Could we capture the trace of an expert through a large complex collection? 2. Could this trace be reused by the same expert? 3. Could the trace could be reused by other experts?

Pilot observations of hospital based physicians revealed that they routinely use numerous, diverse, physically and logically separated systems. One emergency physician used twenty separate systems in an hour, including telecommunication and messaging tools, computer information systems, and printed records. To be useful, any method of capturing the trace of experts through this information space would have to span multiple disparate systems. Our plan to automatically record the trace of an expert through a single system was obviously too limited.

3. Further Refinement: Capturing Bundles

Whether from one system or many, how can one capture expert information selections without imposing additional overhead on the expert? Requiring additional effort would be feasible only if there

were clear benefit to the performance of the expert's task. Reviewing our field observations, we noted episodes of experts assembling *bundles*, organized collections of information that support specific tasks, and envisioned an electronic "scratchpad" to which a clinician could copy excerpts from digital collections and group them into bundles.

To verify our observations about bundles and determine how they are used or reused, we returned to the field, observing clinicians in an intensive care unit (ICU) over several months. There we observed repeated instances of clinicians selecting, organizing,, annotating, and often sharing subsets of relevant information, usually drawn from multiple sources. Bundles took many forms, from formal structured collections meant for the permanent record to informal, temporary "back of the envelope" creations, analogous to observations from earlier protocol analysis. We concluded that bundles of highly selected, organized, and annotated information are routinely used to solve problems and maintain situation awareness. A more complete description is published elsewhere [4].

Based on this work in the ICU, we are developing technology to facilitate the assembly, use, and reuse of bundles of information. Our prototype application, SLIMPad [3] provides flexibility in information selection and arrangement, but unlike a paper scratchpad, maintains links to source data, so that contextual or related information can easily be obtained.

4. Challenges for Digital Libraries

A full description of bundles and their properties is published elsewhere [4]. Our observations of experts and their use of bundles to manage information suggest some challenges for digital libraries as they extend into the workplace:

Collaboration. The "user model" for this work is not a single person but a group. Members have roles that although professionally and formally defined, are also dynamic and socially negotiated. Bundles we observed in the ICU facilitated multi-author, multi-user collaboration.

Multithreading. There is not one task but many, with frequent interruptions, distractions, simultaneous competing demands, and changing priorities. Bundles were used by clinicians to re-establish situation awareness, resume tasks, and transfer care.

Physicality. Although the care of complex acutely ill patients is clearly information intensive, it remains primarily and undeniably physical: it happens at the bedside. The physical properties of bundles we observed permitted tight integration of information tasks with the clinical tasks they support.

Informality and Flexibility. Information in clinical work can be dynamic, uncertain, sensitive, or highly context dependent. The diagnosis and management plan for a patient may be an evolving, socially constructed understanding rather than clear cut, predictable, and proceduralized. Systems that demand precise, explicit expression of categories, relationships, and interpretations may unnecessarily increase an already high cognitive load [6]. Bundles as we observed them were often flexible tools that allowed for the often tentative, imprecise, uncertain changing nature of clinical information.

5. Final Remarks

We have established the creation and reuse of bundles of information elements as common occurences in carrying out tasks in the information-rich setting of an ICU. We believe that effective use of digital libraries and other information sources to support performance of complex tasks can be enhanced with a simple but flexible digital analog to these bundles. We have constructed a prototype that offers this functionality.

The multiple observational methods we employed and the multidisciplinary composition of our team has enriched our observations and analysis. By alternating fieldwork with technology development we have iteratively refined our understanding of the users and their tasks, improving, we hope, the usefulness of the technology we are developing. Details of the technology to support bundles, as a form of superimposed information, are published elsewhere [3, 7].

Near-term plans for our group include extending our observational work regarding bundles to other domains, e.g., aircraft maintenance or forest management; working with critical care clinicians to obtain feedback on the technology (SLIMPad); developing specific technology to support a medical task, and further developing our approach to providing generic technology for superimposed information.

6. Acknowledgements

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